CORPS OF ENGINEERS

Limited Energy Study
Thermal Storage at
Central Chilled Water Plant
Fort Leonard Wood, Missouri

FINAL SUBMITTAL

May 31, 1996

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SECTION 1

EXECUTIVE SUMMARY

A. Introduction

The Scope of Work (See Appendix A) called for the study of the economic feasibility of providing a cold thermal storage system at the central chiller plant serving the Fort Leonard Wood 600 Area in order to reduce electrical demand charges.

In the Entry Interview, Mr. Doug Cage requested that the analysis include the potential for expansion of such a system to serve the 700 and 800 Areas as well. It was agreed that this would be done if the analysis indicated that a cold thermal storage system would be economically feasible for Area 600. Essentially, the systems are modular in nature, so that installed costs would be a multiple of the number of Areas served, not including any extraordinary costs which might be incurred as a result of special conditions which might be encountered as a result of system expansion.

B. Building Data

The 600 Area study area is comprised of two different build types, mess halls and barracks. The mess halls are all essentially identical with the exception that site orientation varies by building. The same is true for the barracks buildings. The following table summarizes building data.

BUILDING TYPE	QUANTITY	FLOOR AREA EACH
Barracks	10	25,878 sq.ft.
Mess Hall	4	7,140 sq.ft.

C. Present Energy Consumption and Demand

A baseline case was calculated under the basis that the future chilled water plant for the area under analysis would be served by a centrifugal chiller. this was done because there is no existing baseline condition against which thermal storage systems may be compared. The existing chiller serves Area 600 plus a portion of Area 700. In addition, its age is such that it is reasonable to expect that it will be replaced in the near future. Assuming that replacement would be done by centrifugals is, we believe, both reasonable and proper.

Electrical energy and demand data for this "Base Case" are as follows:

Peak electrical demand:	679 KWD
Peak energy demand:	2,317,000 BTUH
Annual demand charge costs:	$50,395

Annual electrical usage:	1,436,000 KWHR
Annual energy usage:	4,900,000,000 BTU
Annual energy cost:	$35,895

Total annual utility cost = $86,290
(demand plus usage)

No fuels other than electricity are involved in this study.

D. Energy Conservation Analysis

1) ECO's Investigated

There are two main approaches to cold thermal storage, and both of these were evaluated. One approach uses what is termed an "ice-harvesting" or "ice-shucking" approach, in which thin layers of ice are cyclically built-up on vertical plates and dropped off into a bin below. This bin of ice chips then becomes the means of providing chilled water. The other approach will typically freeze ice in a solid block, perhaps around a bank of pipes during the ice building phase. At the end of the ice building phase, the pipes will circulate water through them which gradually melts the build-up ice, and simultaneously chills the water passing through them. We have referred to these systems as "ice tanks."

The ice harvesting system has the benefit of being able to simultaneously provide chilled water while it continues to build ice. No separate ice-build time is needed. The ice tank system cannot do this. Therefore, for buildings which require cooling at night (such as the Barracks), a separate conventional chiller is required for this duty so that the ice tanks can recharge. The cost and effect of this extra chiller has been included in ice tank calculations.

For each system several combinations of chiller"run"/chiller"off" hours over a 24 hour day were evaluated. Each combination became a separate ECO. Such combinations result in variations in thermal storage volume requirements, chiller plant tonnages needed, and energy consumption. These combinations were generated in order to arrive at the optimum for both first cost and energy consumption.

ICE HARVESTING SYSTEMS

Appendix C contains manufacturer's literature for a typical ice harvesting system. Five alternative systems were evaluated, utilizing various combinations of run time vs. off times, and in addition varying the amount of time the systems ran making ice to the amount of time they ran as conventional chillers. The five systems analyzed are summarized in the following table.

ECO#	HOURS MAKING ICE	HOURS AS CHILLER	HOURS "OFF"
IH-1	8	16	0
IH-2	8	10	6
IH-3	12	12	0
IH-4	12	6	6
IH-5	8	13	3

The ice harvesting system has the ability to continue to produce chilled water during the hours it is in the ice-making mode, due to the fact that the generated ice is de-coupled from the ice-making apparatus. It is therefore available as a separate chilling source. Therefore, the columns labeled as "hours making ice" should not be interpreted as though chilled water cannot be produced during those hours. It simply means that the mechanical refrigeration system will be making ice during those periods.

ICE TANK SYSTEMS

Appendix C contains manufacturer's literature for a typical ice tank system. As with the ice harvesting systems, a total of five alternative systems were evaluated with different mixed of chilling, ice-building, and off hours over a 24-hour period. The following table summarizes these combinations:

ECO#	HOURS MAKING ICE	HOURS AS CHILLER	HOURS "OFF"
IT-1	8	16	0
IT-2	11	13	0
IT-3	8	10	6
IT-4	11	7	6
IT-5	11	10	3

2) ECO's Recommended

None of the ECO's can be recommended.

3) ECO's Rejected

None of the ECO's met the required SIR hurdle of 1.25 and therefore all ECO's are rejected. The conclusion is that cold thermal storage is a non-feasible approach to reducing utility costs at Fort Leonard Wood. The reasons for this are very basic.

First, cold thermal storage systems are extremely expensive to install, compared to

conventional chilled water generators such as centrifugal chillers. The difference in first costs can be amortized over a reasonable period of time, but only if demand and energy charges avoided are high, such as exist on the east coast of the United States. However, the rates being charged at Fort Leonard Wood are among the lowest in the country. The table on page 3-3 from the 7/95 issue of Energy User News reflects this. It shows that, at the current rate of 2.50 cents per KWHR, had Ft. Leonard Wood's utility company been included in this list it would have been one of the cheapest rates in the country, ranking in the top 2.5% of those listed. While this table reflects energy charges only, it is generally the case that energy rates and demand rates go hand-in-hand. Such systems can also be made feasible if the local utility has financing or cash contribution incentives which can be applied against first costs. However, the local utility has no such programs available.

A contributing factor which hurts the viability of cold thermal storage is the need to have cooling available at night for the Barracks building. Most cold thermal storage systems are successfully employed only on buildings which have a regular "down time" such as office buildings, which are closed at nights and over weekends. Such downtime allows the ice system to devote itself exclusively to re-charging of the ice tanks, without the need to simultaneously provide cooling. A need for concurrent cooling drives the installed cost of the system up very significantly.

4) ECIP Projects Developed

None. See Table 1.1 at end of this Section.

5) Non-ECIP Projects Developed

None. See Table 1.1 at the end of this Section.

6) Operational or Policy Change Recommendations

None. Thermal storage is not economically attractive for Fort Leonard Wood.

E. Energy and Cost Savings

See Table 1.2 at end of this Section.

ECO	COST($)	ANNUAL ENERGY SAVINGS*	ANNUAL COST SAVINGS**	SIR	SIMPLE PAYBACK PERIOD(YRS)	ANALYSIS DATE
IH-1	948,394	11.3	$ 9,485	.15	99.99	8/21/95
IH-2	2,231,477	-209.9	$43,070	.28	51.81	8/21/95
IH-3	938,656	- 15.2	$ 9,500	.14	102.91	8/21/95
IH-4	1,174,666	-216.8	$42,898	.54	27.38	8/21/95
IH-5	1,067,969	- 54.4	$46,956	.65	22.74	8/21/95
IT-1	536,849	11.3	$15,200	.42	35.32	8/21/95
IT-2	648,009	74.1	$19,963	.46	32.46	8/21/95
IT-3	1,048,431	9.4	$48,552	.69	21.59	8/21/95
IT-4	968,714	41.6	$49,356	.76	19.63	8/21/95
IT-5	759,010	50.3	$49,574	.97	15.31	8/21/96

* Savings are in units of thousand of watt-hrs per year.

** Includes savings due to electrical demand charge avoidance.

TABLE 1.1

LIFE CYCLE COST ANALYSIS SUMMARY

ECO	TOTAL POTENTIAL ENERGY SAVINGS*	TOTAL POTENTIAL COST SAVINGS**	PERCENTAGE OF ENERGY CONSERVED	ENERGY USE BEFORE IMPLEMENTATION*	ENERGY USE AFTER IMPLEMENTATION*
IH-1	226	$141,412	0.8%	28716	28490
IH-2	-4198	$635,640	-14.6%	28716	32914
IH-3	-304	$135,338	-1.1%	28716	28120
IH-4	-4336	$632,896	-15.1%	28716	33052
IH-5	-1088	$697,342	-3.8%	28716	29804
IT-1	226	$226,452	0.8%	28716	28490
IT-2	1482	$298,903	5.2%	28716	27234
IT-3	188	$722,684	0.7%	28716	28528
IT-4	832	$735,463	2.9%	28716	27884
IT-5	1006	$738,911	3.5%	28716	27710

* Units are in thousand of watt-hour.
** Includes savings due to electrical demand charge avoidance.

TABLE 1.2

ENERGY AND COST SAVINGS SUMMARY

(Note: Negative numbers indicate that ECO consumed more energy than base case.)